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Research article

Chemical control of rice brown spot (*Bipolaris oryzae*) in Paraguay

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Abstract: Rice brown spot produced by *Bipolaris oryzae* is one of the most prevalent fungal diseases in Paraguay and it is associated with rice brown spot, which can decrease yield and seed quality. The research work was carried out in the 2016 crop season in the experimental plot of a private rice producer, located on the district of San Juan Bautista, department of Misiones, Paraguay with the aim of evaluating fungicides for the control of rice brown spot and its effect on yield crop. The treatments consisted on the application of a mixture of fungicides, Azoxystrobin 20% + Difenoconazole 12.5% (400 cc ha^{-1}) at different rice growth stages. All treatments with fungicides decreased rice brown spot incidence significantly and increased yield compared with non-sprayed control. Fungicides applied at R2+R4 and at R2+R3a+R4 resulted in a lower average incidence of rice brown spot (17–15%).
Keywords: *Oryza sativa* - *Bipolaris oryzae* - Rice brown spot - Chemical control.

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INTRODUCTION

Rice is affected worldwide by countless diseases produced by fungi, bacteria and viruses that have influence in the production and sanitary quality of the seed (Ou 1985). In Paraguay, diseases produced by fungi that cause foliar spots are *Bipolaris oryzae* (Breda de Haan) Shoemacker, *Alternaria padwickii* Ganguly M.B. Ellis, *Pyricularia grisea* Cav, *Cercospora* sp., *Microdochium oryzae* Hashioka & Yokogi (Quintana *et al.* 2016). Among the foliar diseases that occur in rice crops, the rice brown spot produced by Bipolaris oryzae is one of the diseases with more prevalence in the different production regions of the country (Arriola 2017). The brown spot is one of the main diseases that cause spots on grains and it can cause damage from 12–30 % on the weight of the grains and from 18–22 % in the number of whole grains per panicle, besides causing broken grains, reduction of viability, loss of quality, for producing dark plaster like grains (Prabhu & Filippi 1997, Guimaraes 2002). In favorable conditions, it can cause up to 50% of damage and up to 35% of loss of germination of the seeds (Balardin & Borin 2001).

The grain spotting in the region has been rising in countries like Brazil, Argentina and Paraguay and the majority of the commercial cultivars in use are susceptible to this disease. Farias *et al.* (2011) reported the prevalence of *Bipolaris* spp. in spotted seed from Rio Grande do Sul, Brasil. In Argentina, it's frequent to find the presence of *B. oryzae* in rice seeds from commercial fields from the Northwest of Argentina (Guimaraes 2002). In our country, the seed analysis made between the years 2011–2013 reported that *B. oryzae* was one of the species with major incidence on seeds (Quintana *et al.* 2017).

Chemical control against foliar pathogen has proven to be efficient in experiments made in different countries (Ottoni *et al.* 2000). In this country published information on chemical control on rice crop is scarce and the application of fungicides is recommended during the R3 state as a first application and the second application at R4. The objective of this investigation was to evaluate a mixture of triazole fungicide + strobilurin applied on different rice growth stages and to evaluate the effect of it on performance and grain quality.

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MATERIALS AND METHODS

The research work was carried out in the district of San Juan Bautista Department of Misiones (Paraguay), during the 2016 crop cycle. The experimental design used was complete block randomized with four replications, each experimental unit had 12 rows with a separation of 0.17 m between them. The variety evaluated was IRGA 424. The treatments consisted in the application of a mixture of fungicides: Azoxystrobin 20% + Difenoconazole 12.5% in a dose of 400cc per hectare mixed with 400 cc of oil (Nimbus) applied in different growth stages of the crop (Table1).

Table 1. Fungicide application scheme on different rice crop growth stage on IRGA 424 cultivar.

Treatments		Growth Stages
T1azoxystrobin 20% + difenoconazole 15,5%	0	------------------
T2 azoxystrobin 20% + difenoconazole 15,5%	R2	Collar formation on flag leaf-booting
T3azoxystrobin 20% + difenoconazole 15,5%	R3	Panicle exsertion from boot, tip of panicle is above collar of flag leaf
T4 azoxystrobin 20% + difenoconazole 15,5%	R4	One or more florets on the main stem panicle has reached anthesis
T5azoxystrobin 20% + difenoconazole 15,5%	R4 + R6	Antesis + milkygrain
T6 azoxystrobin 20% + difenoconazole 15,5%	R2 + R3	Collar formation on flag leaf-booting + panicle exsertion from boot, tip of panicle is above collar of flag leaf
T7 azoxystrobin 20% + difenoconazole 15,5%	R3 + R4	panicle exsertion from boot, tip of panicle is above collar of flag leaf + anthesis
T8azoxystrobin 20% + difenoconazole 15,5%	R2+R3+R4	Collar formation on flag leaf-booting + panicle exsertion from boot, tip of panicle is above collar of flag leaf + anthesis

Source: Counce *et al.* (2000)

Extraction of samples to evaluate incidence and severity of rice brown spot

Samples of diseased plants were extracted 11 days after the last application of the fungicide (filled grain). From each experimental unit 5 plants were collected from the central row which to calculate the percentage of tillers affected with foliar spot in accordance with the Standard Evaluation System for Rice (IRRI 1988).

$$\text{Incidence (\%)} = \frac{\text{T}}{\text{TT}} \times 100$$

Where, T= N° of tillers affected and TT= N° total of tillers.

To determine severity on the same samples the diagrammatic scale were used (Lenz *et al.* 2010).

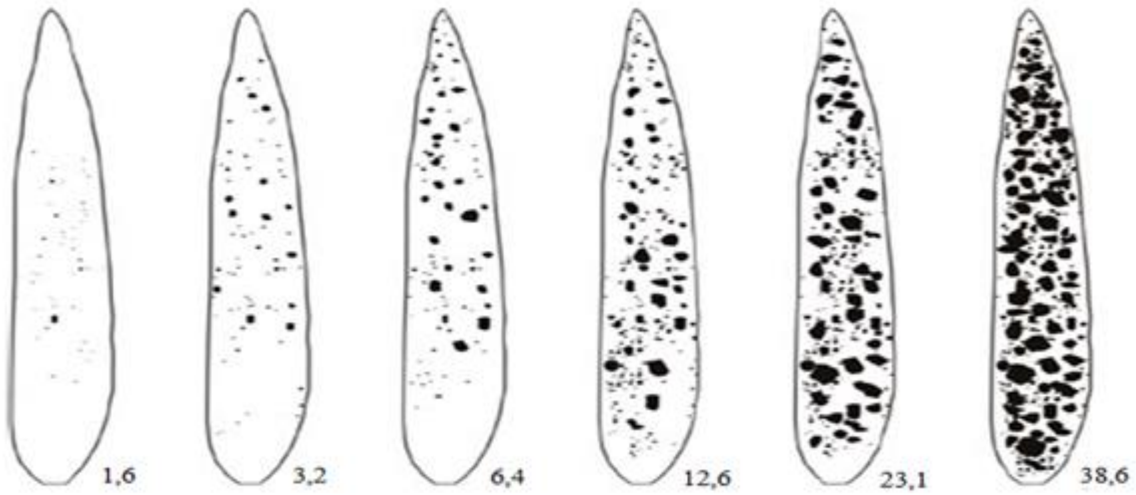

Figure 1. Diagrammatic Scale of rice brown spot (*Bipolaris oryzae*) with different levels of disease severity (%).

Yield and weight of thousand seeds evaluation

To evaluate the crop yield and weight of 1000 seeds, 3 m^2 of the central rows were harvested and processed. The corresponding threshing was done manually and the weight corrected at 12 % of humidity and expressed in kg ha^{-1}. To evaluate the weight of 1000 seeds, 500 seeds were counted to be weighed and then multiplied by 2.

Data Processing

For analysis of variance was using the statistics program Infostat version 2013 and the average comparison was made through the Tukey test with 5 % of error probability.

RESULTS AND DISCUSSION

Incidence and severity of the brown spot

ANOVA demonstrated high significance in the variables incidence and severity of brown spot ($p<=0.05$). All treatments with fungicides decreased rice brown spot incidence significantly and increased yield compared with non-sprayed control. The lowest levels of brown spot were produced with two (R3+R4) and three applications of fungicide (R2+R3+R4). With one fungicide application (R4) and two applications (R4+R6 y R4+R6 y R2+R3 reductions of 34, 36, 33 and 28 % of brown spot were obtained. These results are similar to the works of Bordin *et al.* (2016) who reported a reduction of 50% in the incidence percentage and 2.7% of the severity of brown spot with fungicide application. In this study, the lowest severity was produced on T7 and T8 (Table 2).

Table 2. Incidence and severity of brown spot on var. IRGA 424 with chemical protection in different rice growth stages.

Treatments	Incidenc (%)	Tukey (5%)	Severity (%)	Tukey (5%)
T1 Control	90.0	D	6.4	E
T2 Application at R2	65.7	C	2.4	B
T3 Application R3	72.2	C	2.8	B
T4 Application R4	33.5	B	2.4	B
T5 Application R4, R6	32.7	B	2.0	B
T6 Application R2, R3	35.5	B	2.4	B
T7 Application R3, R4	18.3	A	0.4	A
T8 Applic. R2, R3, R4	15.7	A	0.8	A
FC	42.2**			43.3**
CV	19.8			19.9

Note: FC- Calculated F in ANOVA; CV- coefficient of variation; **- Highly significant.
Different letters indicate significant differences ($p \leq 0.05$).

Grain yield and thousand weight seeds

ANOVA analysis demonstrated a high significance in the variable yield ($p<=0.05$). All treatments with fungicides increased yield compared with non-sprayed control. With three fungicide applications (R2+R3+R4) the increments was of 23% (Table 3). These results are similar to those reported by Dallagnol *et al.* (2006), who indicate that the application of fungicide results in an increase of the productivity of the grain between 6.1–42.1%. Santos *et al.* (2009) report increments of 34% with two fungicide applications compared with non-sprayed control. Celmer *et al.* (2007) indicate that with applications of triazole fungicides + strobilurin up to 52 % of increment in grains was obtained. In relation to thousand seeds weight, the analysis of variance resulted in not significative differences, which does not match with the work made by Bordin *et al.* (2016), who found increments in the weight of a thousand seeds after performing 3, 4 and 5 applications of fungicides at levels of 11.2 %, 13.8 % and 23.6 % respectively.

Table 3. Thousand seed weight and yield of var. IRGA 424 with chemical protection in different rice growth stages.

Treatments	Thousand seed weight (g)	Yield (kg ha^{-1})	Tukey 5%
T1 Testigo	24	7576	A
T2 Aplicación R2	25	8436	BC
T3 Aplicación R3	25	8934	BC
T4 Aplicación R4	24	9000	C
T5 Aplicación R4, R6	26	9690	C
T6 Aplicación R2, R3	26	9616	BC
T7 Aplicación R3, R4	25	9556	C
T8 Aplicación R2, R3, R4	26	9816	BC
FC	2.17^{ns}	9.8**	
CV	4.17	5.6	

Note: FC- Calculated F in ANOVA; CV- coefficient of variation; **- Highly significant.
Different letters indicate significant differences ($p \leq 0.05$).

CONCLUSIONS

The application of fungicides in different rice growth stages provided significant reduction on the incidence and severity of the brown spot on the cultivar IRGA 424, which was reflected in the performance of the grains and was influenced by the period of application.

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